Gini's Transvariation Analysis: An Application on Financial Crises in Developing Countries

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Gini's transvariation analysis: an application on financial crises in developing countries

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Abstract: The damage and the recurrence of financial crises have increased the concern of investors and policymakers on one hand and the interest of macroeconomists on the other. This paper presents an original non parametric methodology, whose aim is to give a very intuitive and rigorous method for variable selection in order to analyze financial crises. The transvariation analysis compares the distributions of two different groups of countries (sound and distressed) with respect to a single macroeconomic variable and selects the indicators on the basis of a low transvariation probability index. The current account deficit to GDP ratio, differently from other studies on financial crises, seems to be a suitable variable in discriminating distressed countries from sound ones, and the case of Argentina and Turkey confirms this finding.

1 Introduction

During the last century, financial crises have been a recurrent and damaging phenomenon that not only has caused disruption to the affected economies, but also has worsened agents' expectations toward a future seen ever more uncertain. A series of panics and crises happened in the Pre-World War II period, from 1814 up to the Great Depression of 1929 (Calomiris-Gorton 1991), and many others occurred in the Post-World War II period as the collapse of the Exchange Rate Mechanism (ERM) of the European Monetary System in 1979 and in 1992, the Mexican crisis of 1995, the Asian Crisis of 1997, the Russian crisis of 1998, the Argentinean crisis of 2001. Nevertheless as Bordo and Eichengreen

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(2000) show, there were no major crises in the Bretton Woods era, whereas the post-1971 period has experienced numerous and disruptive financial crises. Bordo et al. (2001) find that financial crises after 1971 are different in terms of frequency and recurrence (only the period 1920-1930 may be compared with the recent post-1971 era), but in terms of output losses and length little has changed. The recent period is better than the inter war period, but still fairly bad. In particular, banking and twin crises (e.g. banking and currency crises) are more frequent than in every period (except the inter war period) and currency crises are much more frequent. In addition, they observe that emerging countries are more prone to crises. This thesis is corroborated by the recent findings of Reinhart and Rogoff (2009), who stress the weakness of the 'this time is different' thesis. In particular, it is an illusion to believe that thanks to better macroeconomic policies and better screening by lenders 'the world is not likely to again see a major wave of default'. Recent experience show the recurrence of serial defaults even though some countries thanks to better institutions are 'graduating' from a history of serial defaults.

Starting from these stylized facts an obvious concern of empirical research, financial institutions and private investors has been the predictability of financial crises. Many academics and also some institutions as the IMF and Standard and Poor's, have introduced some indicators (or set of indicators) that could predict financial crises. The scope of the present analysis is to contribute to this literature on Early Warning Systems (EWS), by introducing a methodology (transvariation analysis) that is both rigorous and easy to apply. The result of the present research should induce to devote more attention to real factors in predicting financial crises, in particular to reassess the importance of the current account component of the balance of payments, in contrast with the recent almost exclusive attention to the financial account side. In particular, contrary to the current stream, which disregards the importance of current accounts deficits, focusing mainly on the financial account (and the related currency and maturity mismatch), our analysis suggests that unsound current accounts can strongly predict financial crises and the current account sharply discriminates between countries that are prone to crises and those who

are not. The analysis does not underestimate the important recent contributions of Calvo (1998), who stressed the crucial role played by a weak financial sector, rather we want to stress that the current account more clearly than the financial account has been a key factor in distinguishing defaulting countries from sound countries.

The rest of the paper is organized as follows. Section 2 briefly introduces the role played by current account in the recent literature on financial crisis.. Sections 3 and 4 focuses on the evolution of EWS in terms of the methodologies used, tasks and main results. Sections 5 and 6 introduce the transvariation analysis methodology, the application and present the main results. Section 7 focuses on the importance of the variable current account in assessing the difference between Argentina and Turkey crisis episodes. Section 8 concludes the article.

2 The role of current account deficits in predicting a crisis

Two big waves of current account deficit hit world economy in the last 30 years: the first, between the end of the '70s and early '80s in Latin America, and the second in the '90s in East Asia. Both led to significant crises, the second being even bigger. The important point is that emerging market crises have large macroeconomic effects. In particular when capitals flow inward, a country can run large current account deficits but when capitals flow out the current account has to be rebalanced very quickly, which is often economically and politically very costly. Indeed domestic spending must decline or taxes must increase relative to output to re-establish the balance. A fall in domestic spending generates a decrease in the output of non-tradables, while a rise in the output of tradables is required to improve the current account. This will occur through a rise in the price of tradables relative to non-tradables, which corresponds to a depreciation of the real exchange rate. These effects are painful when much of the domestic debt is denominated in foreign currency and/or is short term. In the 1980's emerging market economies (EMCs) had large current account deficits to GDP ratios. In 1982 in Latin America the

deficit was 5 percent of GDP and then came the crises inducing the deficit to shrink to 0.3 percent of GDP in 1983. Finally in 1984 Latin America ran a surplus of 0.8 percent of GDP. However emerging market economies were close to balance between 1983 and 1991, but then came a period of generous market financing to East Asian countries in the '90s and in 1996 the deficit in East Asia was 2.1 percent of GDP. When the 1997 crisis occurred East Asians were compelled to redress the balance running a surplus of 4.7 p.c.in 1998[4]. In both episodes sudden cessation of capital flows ('sudden stops') forced the current account deficit to fall, the exchange rate to depreciate and the output to fall dramatically. Ever since emerging market economies seem to have learned the lessons and they were running current account surpluses causing on the other hand what has been named the problem of 'global imbalances'[5], with developed economies heavy indebted with emerging economies. In other words, EMC's have realized that the counterpart of capital inflows was running huge current account deficits, which implied financial crises. In particular the interaction between irresponsible lending - moral hazard fostered by international institutions -, and unregulated borrowing - borrowing short term and in foreign currency - has proved fatal to emerging market countries. In the last decade the result has been on one hand to improve the current account sustainability and on the other hand the fear of running current account deficits. The latter implies that the governments of EMCs have converted capital inflows in foreign currency reserves.

The role played by current account deficits in triggering a crisis has been central to many models since the late '70s. The first generation model of financial crises introduced by Krugman (1979) who developed for pegged exchange rate regimes a model introduced by Salant and Henderson (1978) pointed out the relevance of having consistent fiscal policies and exchange rate regimes[6].

Second generation models have been introduced by Obstfeld and Rogoff (1995) to

[4]See Williamson (2005) for a detailed account of how current account deficit led to crises in emerging market countries.

[5]For an account on global imbalances, its causes and effects see Eichengreen (2007), Edwards (2007), Wolf (2009).

[6]Krugman's model has been perfected by Flood and Garber (1984), who determined the timing of a crisis.

deal with EMS crises in the 1990s. The main tenet of these models is that crises are self-fulfilling phenomena in a context of multiple Nash equilibria. According to these models, while good fundamentals avoid crises and really bad ones lead to crises, there are certain intermediate values of fundamentals in which both, the good and the bad scenario, are possible outcomes. The implications of these models were that having sound current account does not always guarantee that countries will escape a crisis.

In the last decade many authors have analyzed whether crises were preceded by current account deficits or not. Some authors like Radelet and Sachs (1998a, 1998b), have stressed the role of financial panic as an essential element in exacerbating the crises. The key elements of the Asian financial crises (AFC) were that the crises were largely unanticipated, they involved considerable lending to debtors that were not protected by state guarantees, economic fundamentals while not completely sound, were substantially good. The only critical points such as growing current account deficits, overvalued exchange rates and slowing export growth were not so serious as to predict an impeding major crisis. Only the financial sector with its large imbalances in the maturity and denomination of the currency, raised the most serious doubts about the stability of the system. Thus the crisis is due to co-ordination failure and not to bad fundamentals in the current account.

A different perspective has been put forward by Corsetti, Pesenti and Roubini (1999) who has stressed the role of moral hazard caused by money-back guarantees for depositors and limited liability for lenders that led to excessive investment (over-investment problem). Thus the problem was not one of panic and failure of co-ordination among creditors, but one of over-investment. These authors opened the way to third generations model of crisis, stressing again the role of sound fundamentals.

Both interpretations deserve attention, because they focus on key elements of the East Asian financial crisis. Radelet and Sachs' interpretation helps us understanding that some indicators, usually adopted to screen the presence of distress, are no longer the unique ones (in particular, budget deficits as to the fiscal policy and interest rates as to the monetary policy), while Corsetti et al. (1999)'s focus on the important role played by moral

hazard in the financial and corporate system.

Some authors, as Chang and Velasco, have formalized the maturity mismatch problem, and Aghion, Bacchetta and Banerjee (2000, 2001) have focused their attention on the currency mismatch phenomenon. This last approach has restored the relevance of balance sheet, though still including the possibility of multiple Nash equilibria[7].

Some studies building on Calvo have stressed the role of capital account rather than current account imbalances. Indeed Calvo (2000) has focused its attention on the vulnerability of the balance of payments caused by capital reversals[8]. He has shown how a currency crisis is possible even in the absence of a prior current account deficit. Edwards (2002) conducted a massive investigation on the importance current account and questioned its relevance, concluding that it is not possible to support the thesis that countries with high current account deficits (arbitrarily defined) must face a crisis. However he added that more broadly defined current account deficits - in terms of the costs involved in running very large deficits - almost inevitably lead to a crisis. Moreover if Africa is excluded - and Edwards provides reasons to do that - even current account strictly defined raises the probability of crisis. Finally, he concludes contrary to recent claims suggesting the irrelevance of current account deficits, 'large deficits should be a cause for concern'[9]. These conclusions have been strengthened by further research of the same author (Edwards (2004)).

To summarize, the fear of running current account deficits may be due to the fear of generating a currency mismatch on the balance sheet; large current account seems to trigger capital outflows, when signals of vulnerability appear either at the domestic or the

[7]This has led some authors, as Alonso Neira (2005), to question whether we should speak of third generation or whether these models are just an extension of the two previous ones. But while in the first generation models a crucial role was played by the fundamentals of the economy (current accounts, fiscal deficits) in third generation models attention is devoted to banks', firms' and the financial sector's balance sheet, in order to single out the variable(s) that could help predict the crisis. Third generation models were developed out of the consideration that crises in the late 1990s occurred in countries with sound fundamentals, so the weakness was looked for in the banking and financial sector.

[8]The idea that currency crises are due in our days to capital accounts problems rather than current account deficit had been presented at the Munich Lectures by Dornbusch in 1998 (see Dornbusch and Fischer (2003).)

[9]Edwards (2005) has analysed current account deficits over the period 1970-2002, studying the implications in terms of GDP loss for the U.S. of redressing the current account deficit.

international level; re-establishing the balance in the current account requires a depreciation in the real exchange rate, which is painful in the presence of currency mismatches; the latter is worsened when debt is short term and can easily fly out. Finally the 'fear of floating', generated by the desire to avoid currency mismatches has led to undervalued exchange and current account surpluses, which is what we currently observe in most EMCs and on the other has concurred to generate US current account deficits (the US government knows it will never suffer from the double mismatch occurred to EMCs). In what follows we want to show that the fear by EMCs is well grounded on the basis of the fact that the current account deficit is the best predictor of an impending crisis.

3 Non parametric EWS models

Theories on crises are very important in determining the list of economic indicators, but EWS models have the power of testing whether these indicators are good predictors of financial crises without estimating any particular speculative attack theory. The Early Warning Systems models can be divided into three groups in terms of methodologies used:

- non parametric methodologies (signal approach);
- parametric methodologies (probit-logit, multinomial logit, markov chains);
- non-parametric and parametric methodologies (event studies supplemented by multivariate regression).

We would like to focus on the non-parametric methodologies since the transvariation analysis is part of this group. The event studies were used for example by Eichengreen, Rose and Wyplosz (1995), Frankel and Rose (1996), Edwards and Santaella (1993), and more recently by Aziz, Caramazza and Salgado (2000). Edwards and Santaella (1993) combines non parametric tests with cross - country regression to understand 48 devaluations in the developing countries that took place during the Bretton Woods period (1945-71). The control group consists of the 24 developing countries that maintained a fixed

nominal exchange rate for at least ten years. They summarize the behavior of some macroeconomic indicators in the two groups of countries by comparing the statistical distribution of the two groups, using quartiles.

Eichengreen, Rose and Wyplosz (1995), Frankel and Rose (1996) combine event study analysis with the use of the graphical techniques and multivariate regression, the first paper uses multinomial logit, the second uses probit models, estimated with maximum likelihood. In both studies the control group is given by the 'tranquil' period for the same group of countries. In the graphical approach, a graph for each variable is constructed in order to study a particular 'event' that can be a currency crash, but also a depreciation event. A homogeneous group of countries that experienced this event is considered, but the sample is divided into two groups of observations: the 'tranquil' observations, which constitute the control group, and the observations within a certain window of time that comprises the event. For each indicator, the average value of the 'tranquil' period is thus compared to the average values around the event and the differences between the two groups of observations are tested for statistical significance. The advantages of the event studies methodologies, as underlined by Aziz, Caramazza and Salgado (2000) can be found in the simplicity of the approach, it does not impose parametric structure on the data so, on the one hand, it is more informative in extracting patterns of behavior and at the same time it does not encounter the problems related to statistical inference.

The most significant drawback is the fact that the approach is univariate, though this problem is usually overcome by supplementing the univariate analysis with more rigorous multivariate regression analysis (generally probit - logit). A second problem with the graphical event study is that a number of diverse countries are included in the sample making it difficult to draw conclusions from the average behavior of variables. Aziz, Caramazza, Salgado (2000) standardize variables with respect to their country specific means and standard deviations. A third drawback comes from the fact that crisis could be different, so looking at a common pattern across many different crisis could be informative, but can also be misleading, because some particular pattern could be dominating the

common one.

Kaminsky and Reinhart (1997) and Kaminsky (1999) introduce a pure non parametric approach to evaluate the usefulness of several variables in signaling an impending crisis. It can be interpreted as an extension of the methodology used in event studies. The aim of this approach is to monitor the evolution of a number of economic variables, when one of these variables deviates from its 'normal' level beyond a certain 'threshold' value, this is taken as a warning signal about a possible currency crisis within a specified period of time. For each country, crises are identified ex post by the behavior of an index of exchange market pressure, the signaling horizon is the period within which the indicators would be expected to have an ability for anticipating crises (defined a priori 24 months) and the 'threshold' levels are chosen so as to strike a balance between the risks of having many false signals and the risk of missing many crisis. The 'thresholds' are chosen in relation to the percentiles of the distribution of observations of the indicator for each country. Once the critical 'threshold' is chosen, the indicators considered are transformed into binary signals: if a given indicator crosses a critical 'threshold' it is said to send a signal. After having ranked the indicators according to their ability to predict crises while producing few false alarms, the signal approach also tabulates for each of the indicators considered, the average number of months in advance of the crisis when the first signal occurs and the level of persistence of the indicator.

The main drawbacks of this approach are that a variable can send a signal at whatever distance from the critical 'threshold' and that the approach is again univariate. In order to overcome these problems together with other problems, Kaminsky (2006) introduces a multivariate signaling approach, which overcomes the unknown non-linearity that characterizes the crisis phenomena and that is not considered in previous methodologies. The non-linearity comes from two different sources. The first is the disconnect between the different varieties of crisis and 'the one fits all' approach imposed by the previous techniques. Some indicators, for example, may not be important to explain all the crisis, but could be of key importance for a subgroup of observations. The second source comes

from the fact that crisis becomes more likely as the number of fragilities increases. The difference between the multivariate signaling approach and the univariate signaling is explained by the way 'thresholds' are identified, in the latter they are obtained indicator by indicator, in the former they are identified jointly. The new methodology (the regression tree analysis) allows the data to determine the number and characteristics of classes of crisis. The observations are first divided into those observations in periods of crisis and observations in 'tranquil' times. As in the univariate signal approach, the algorithm chooses a 'threshold' for each indicator to minimize its noise-to-signal ratio, then the indicator with the lowest ratio is selected. All the observations are then separated into two groups: those for which the chosen indicator is signaling and those for which the chosen indicator is not signaling and for each group the methodology is repeated. To avoid the perfect fit, the regression tree analysis imposes a penalty on the number of varieties. The adjusted R^2 criterion is used to measure the improvement due to the identification of a new variety. If the penalty exceeds the improvement, the algorithm chooses the previous number of varieties; otherwise the algorithm continues to partition the sample.

4 What variables do EWS models consider important predictors?

Eichengreen, Rose and Wyplosz (1995) find that devaluation are preceded by political instability, budget and current account deficits and fast growth of money and prices, in contrast they find that few consistent correlations link regime transition like flotation or fixing to macroeconomic or political variables and they conclude that there are no clear early warning signals of many speculative attacks. Edwards and Santaella (1993) emphasize on the importance of domestic credit and fiscal policy expansion indicators, but also the worsening of the current account deficit and the capital flight in understanding the 69 devaluation episodes object of their study. Frankel Rose (1996) show, in line with most studies, both with graphical and regression analysis, that crashes tend to occur when FDI inflows dry up, when reserves are low, when domestic credit growth is high, when

world interest rates rise and when real exchange rate show overevaluation. On the other hand they put in evidence that current account deficits and government budget deficits do not play a role in explaining crashes. Kaminsky (1999), using the signaling approach, provides some information on the performance of individual indicators in forecasting currency and banking crises. If we consider only currency crises then, according to Kaminsky (1999), high world interest rates, together with increasing gross foreign debt (the ratio of domestic residents' liabilities in banks overseas to foreign exchange reserves), positive capital flight (the ratio of domestic residents' assets in banks overseas to foreign exchange reserves) and the ratio of short term maturity foreign debt to total foreign debt (which captures liquidity problems) are good indicators. If we consider banking crises, then the best indicators are the ones linked to the liberalization of the capital account and the domestic financial sector (M2 multiplier, domestic credit/GDP and stock prices). The indicators that can be excluded from Kaminsky's (1999) univariate analysis are: lending/deposit rate ratio, imports and bank deposits. We would like to notice that the current account deficit/GDP is not part of the list of variables considered by Kaminsky (1999), but other indicators such as exports, imports, the terms of trade and the real exchange rate are analyzed as those variables that are linked with current account problems.[10] The 'new generation' of EWS models tend to focus more on the ability of the models of predicting the timing of the crises (Bussiere Fratzscher, 2006) or on the ability of the models to explain the different varieties of crises (Kaminsky 2006 and Arias and Erlandsson 2005) rather than focusing on the macroeconomic indicators.

5 Transvariation analysis: where do we stand?

As in the event studies, we consider those variables that are suggested by the theory literature on financial crises, in the period that leads up to the event we are interested in. We use annual data and we compare the behavior of two groups of countries: the group of de-

[3]See Kaminsky (1999) for the full list of indicators considered.

veloping countries that experienced a crisis and the group of sound developed countries. Our aim is not to predict the timing of a crisis, but we find much more useful, for policy implications, to study the behavior of macroeconomic indicators that can be controlled by policymakers and to study them enough time in advance in order to be able to implement the right changes. The approach is non parametric, gaining all the advantages of non parametric techniques, and very simple to understand and implement thus in a rigorous way. We consider different episodes of crisis that have different characteristics so we are interested in searching the common elements. Our approach does not depend on arbitrarily chosen 'thresholds' as the signaling approach, but we base our analysis on the calculation of a transvariation probability index that measures the overlapping area between the distributions of the two group of countries considered with respect to each economic indicator. The approach is univariate, but a multivariate version of transvariation analysis, that takes into account the correlation between variables, can be implemented.

The basic idea of transvariation analysis we would like to explain in this paper is quite simple. Let us suppose to face a whole of units (men, families, firms), characterized by several variables (rate of blood pressure, cholesterol level, but also, financial ratios, patrimonial indicators) divide them into two groups, respectively healthy and unhealthy men, distressed and sound firms, safe and insolvent families. Once we report the two density distributions of each variable, each for the two groups, on the same graph, we observe different overlapping areas: the transvariation area. If now we imagine to ignore which of the two groups the different units share, but at the same time we have the task of classifying correctly the units in the two groups by means of only one variable, we can properly do this by choosing the variable whose overlapping area - transvariation - is quite small. Transvariation analysis has been developed by Gini (1916, 1951) in connection with zoological and anthropometric studies. Deutsch and Silber (1997) has used transvariation analysis to study income distribution in Israel. Skirmantas (2005) has used the same approach to verify the physical difference between autistic and healthy children with reference to the two distributions of serotonin. Another approach similar to

the analysis of transvariation is the ‘affinity analysis’ developed by Bhattacharyya (1943), Matusita (1956), Kratzanowski (1995). In the following subsections we will describe the methodology used in detail.

5.1 The methodology: transvariation analysis

Let x_i be any quantitative variable (height, weight, income, inflation, etc.) and K and H two groups of units (men, women, firms, countries, etc.), composed with respect to the same variable, of numerousness n and m. We then define:

- $x_{1,k}, x_{2,k}, ..., x_{n,k}$ as the ordered measures of the units composing group K;
- $x_{1,h}, x_{2,h}, ..., x_{m,h}$ as the ordered measures of the units composing group H.

Chosen the median as the mean value of the distributions, let us assume that the following inequality holds:

$$M_k > M_h. \tag{1}$$

Given (1), if we compare each unit of group K with each unit of group H, getting a total of $n \cdot m$ comparisons, we have that some comparisons obey the following inequality

$$x_{i,k} > x_{j,h}, \tag{2}$$

others respect this relation

$$x_{i,k} = x_{j,h} \tag{3}$$

and finally others follow this inequality

$$x_{i,k} < x_{j,h}, \tag{4}$$

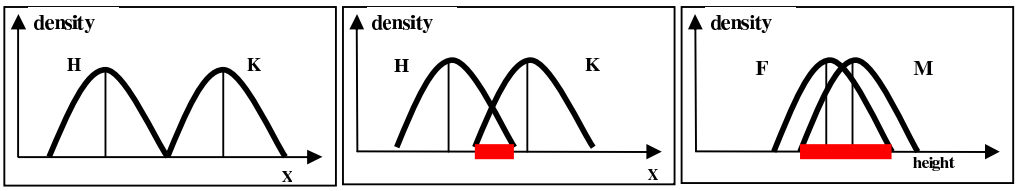

Figure 1: Transvariation area

where i = 1,2,..., n and j = 1,2,..., m. We have transvariation when a part of the comparisons obeys to inequality (4). From a graphical point of view it is possible to draw the transvariation area for relations (2) and (4). If $x_{i,k} > x_{j,h}$, for each of the $n \cdot m$ comparisons, the density distribution of group K is completely separated from the density distribution of group H. Alternatively, if for some cases $x_{i,k} < x_{j,h}$, the two density distributions are characterized by an overlapping area, the area of transvariation. If for a high number of cases $x_{i,k} < x_{j,h}$, then the two density distributions are characterized by a large overlapping area, which corresponds to a lower variable's discriminating power. Rising degrees of transvariation are depicted in figure 1.

The distributions are very well shaped, but this is not a necessary prerequisite of transvariation analysis, being this statistical tool essentially non parametric and, therefore, independent from whatever hypothesis on the distributions of the groups. The transvariation probability index is defined with respect to the median as the following ratio:

$$2 \cdot (T_{h,k}/n \cdot m) \tag{5}$$

where:

- $T_{h,k}$ is the number of cases of transvariation, increased by half of the number of cases in which $x_{i,k} = x_{j,h}$;
- $n \cdot m$ is the number of possible comparisons.

The index is defined in the interval [0,1]. Increasing values of the index involve larger and larger overlapping areas. In the case of equal medians, which imply a perfect overlapping of the two distributions, the index assumes value 1. At the opposite, decreasing

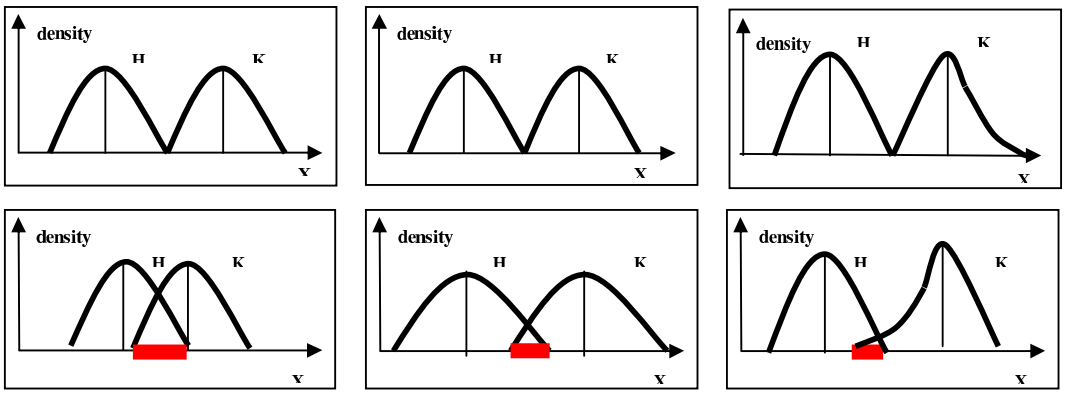

Figure 2: Different causes of transvariation

values of the index are associated with lower and lower overlapping areas. For value of the index equal to zero the two distributions are perfectly separated. The probability of transvariation derives from 3 different causes:

- the distance between the medians of the two groups;
- the degree of variability of the variable;
- the shape of the density distributions.

Given the same variability and the same shape of the two distributions, a lower distance between the medians can produce transvariation. If, on the contrary, we have the same distance between the medians and the same shape of the two density distributions, it is the different variability that can cause transvariation. Finally, given the same distance between the medians and the same variability, transvariation can be primed by a change in the shape. The different causes of transvariation are depicted in figure 2.

5.2 A dynamic integration: speed of run

Transvariation analysis is a relevant expedient to individualize a correct variable in order to classify correctly two groups of statistical units - countries - according to a precise profile, which is to be or not proximate to default in our case. Once individualized the correct variable it is necessary to explain how to use it correctly in a dynamic and not only static framework. It can in fact happen that the available information is not only supplied

for one ‘point’, but also for a span of time as it happens in macroeconomics where the national accounts of a country are available for a series of years. Our suggestion is to use the speed of run. This is the number of times - years in national accounts - the chosen predictive variable maintains the same sign. The change of the sign involves a new begin of the counting. Rationale of this procedure is that the persistence of the sign is a proof of an increasing intensity of the variable and vice versa. In table 1 we supply different examples, assuming the predictive power has negative sign. The time is represented by 6 years.

Table 1: *Speed of run*

year 1	year 2	year 3	year 4	year 5	year of crisis	speed of run
-	-	-	-	-	-	6
-	-	-	+	+	-	1
+	+	-	-	-	-	4
-	+	-	+	-	-	2
-	-	-	-	-	+	0

6 The application

Imagine to position on a univariate plane two groups of countries (sound and distressed) in a period of time before their financial distress, with respect to each macroeconomic variable. Gini’s transvariation analysis measures the distance (in terms of overlapping) between the distributions of the two groups. The methodology selects those variables that better separate the two groups of countries not only in a static, but also in a dynamic framework. Through this methodology only the variables that determine an increasing distance between the two groups, as the year of crisis approaches, are considered the most informative variables for financial distress analysis. In the following application, we would like to focus on two different samples, the first sample reflects the most recent and serious crisis episodes that are linked with default or deep financial and currency crisis that occurred in the nineties, while the second is taken from Frankel and Rose (1996)

dataset which comprises more than one hundred countries.

6.1 The first sample: deep financial and currency crisis of the nineties

In this first sample we construct the group of distressed countries considering, on one side, those that officially and unilaterally declared the impossibility of foreign debt repayment (capital and/or interests) toward other countries or private parties, such as Argentina (2001), Ivory Coast (2000), Peru (2000), Ecuador, Venezuela, Russia, Ukraine, Pakistan (1998), Indonesia (1997) and, on the other side, all those countries that, even though they did not go bankrupt, had to face deep financial and currency crises which determined serious consequences on their entire economic system, such as Mexico (1994 - 1995), Malaysia, Philippines, Korea, Thailand (1997) and Brazil (1999).[11] We construct the group of sound countries considering the developed countries in a tranquil year (1999).[12] We choose to consider the group of sound countries as control instead of the 'tranquil' period because on one hand we are confident of the fact that developed countries can be considered sound and, on the other hand, we would like to avoid imprecise and ad hoc definitions of 'tranquil' periods, that might bias the results. In practice we also consider the information coming from the 'tranquil' periods by comparing the results of transvariation analysis through time in the span that precedes the year of crisis as it will be emphasized in the next section. Both the theoretical and the empirical literature suggest different symptoms to crisis: expansionary monetary and fiscal policies, recessions, real exchange rate appreciations, high inflation, exaggerated credit-cycles, loss of competitiveness and deterioration of the current account, high domestic and foreign interest rates etc. According to these different symptoms we can divide the macroeconomic indicators as follows:

- overborrowing (domestic credit/GDP);
- growth slowdown (GDP growth, real deposit rate);

[11] We consider the year of the crisis and the previous four years.

[12] The developed countries considered are: Austria, Belgium, Luxembourg, the Netherlands, Ireland, Spain, Italy, Germany, France, Norway, Sweden, Denmark, Switzerland, the UK, Iceland, Finland, Australia, Japan, Canada, New Zealand.

- capital account indicators (reserve variation, M2/reserves);
- current account indicators (current account deficit/GDP, trade balance/GDP, investment/GDP);
- monetary indicators (M2/GDP, M2/reserves, nominal deposit rate, real deposit rate, inflation).[13]

We consider the variation of all these variables (except GDP growth, CAD/GDP, TB/GDP), in accordance with Kaminsky (1999), in order to avoid the implicit heterogeneity between the two groups (driven by the fact that we are comparing developed and developing countries) that the variables in levels would imply and that would bias the results. In particular, if we consider the variables in levels, for some indicators, the distributions between the two groups of countries would not overlap. This finding is highly influenced by the fact that the variables in levels emphasize a comparison between developed and developing countries, more than a comparison between the 'sound' and the 'distressed'.

6.2 The second sample: Frankel and Rose dataset

We construct the second sample from Frankel and Rose (1996) annual data on developed countries from 1971 to 1992 and we define the currency crises as a depreciation of the nominal exchange rate of 25 p.c. that is also at least a 10 p.c. increase in the rate of change of nominal depreciation. The sample is constructed similarly to Frankel and Rose (1996) by considering for each country all the observations starting from the year of the crisis up to three years before. The total observations we have for each variable are 261. For the group of developed countries [14] we consider the years 2004,2005 and 2006 in order to maximize data availability. The variables considered are also very similar to Frankel and Rose (1996), we can divide them as follows:

- debt variables (the ratio of external debt to GDP, short term debt to external debt, government debt to external debt);

[13]The source of these indicators is IMF International Financial Statistics Yearbook, 2001.

[14]Australia, Finland, Japan, Spain, Austria, France, Luxembourg, Sweden, Belgium, Germany, the Netherlands, Switzerland, Canada, Ireland, New Zealand, the UK, Denmark, Italy, Norway

- current account indicators (current account deficit/GDP, investment/GDP);
- capital account indicators (reserve variation);
- monetary indicators (M2 growth and inflation);
- a measure of the over borrowing (domestic credit to GDP);
- a measure of recession (GDP growth); [15]

All the variables except CAD (current account deficit) and investment/GDP are in variation terms. Comparing the two datasets we can say that the first dataset covers a small number of relevant crises and the statistical analysis can be compared through time, while the second dataset covers a vast number of observations, it refers to a less restrictive definition of crises and the statistical analysis cannot be compared through time.

7 Results for the first sample

In this paragraph we would like to present the main results referred to the first sample of most recent crises, focusing on the quartile analysis - which captures a preliminary comparison between the two distributions - on the transvariation probability indexes and finally on the speed of run. As specified in the previous paragraph, even though the quartile analysis should be very close to the transvariation probability index results, the index is more rigorous because it includes all those cases in which the causes of transvariation are not linked to a lower distance of the medians and quartiles, but to a different variability or a different shape of the two distributions.

7.1 Quartile analysis

Table 2 reports the quartile analysis results for each variable . We can see that from the table it is possible to compare the distributions of the distressed countries up to 4 years before the crisis, and also the same distributions with the control group. We find this table very informative, because it pictures the difference in terms of values, between sound

[15] The source of these indicators is World Bank, World Bank Development Indicators.

and distressed countries and permits to understand the evolution in time of each variable approaching the crisis. The reserves' variation becomes negative, the ratio M2/reserves increases, domestic credit/GDP - which is an indicator of the fragility of the banking system and also an indicator of the amount of money supply - together with M2/GDP and the real deposit rate, increases. GDP growth, which is an indicator of recession, and inflation decreases. The current account deficit (CAD)/GDP becomes more and more negative approaching the crisis year and the distribution of the distressed countries moves away from the distribution of the sound countries. Investment/GDP and saving/GDP, which can be interpreted as the causes of the deficit, behave in a heterogeneous way. In particular, for these two indicators, the third quartile overlaps with the distribution of the sound countries. The trade balance/GDP is characterized by an almost complete overlapping of the distributions.

7.2 Transvariation probability index

From the transvariation analysis point of view, we can discriminate the macroeconomic indicators into three categories. According to the quartile analysis applied to the first category of indicators (trade balance/GDP, investment/GDP, savings/GDP, M2/GDP, real deposit rate, domestic credit/GDP and inflation) the distressed group's quartiles are not at all separated from the control group's quartiles. This means that the distributions of the two groups of countries, with respect to each of these indicators, overlap. The second group of variables (GDP pro capita, nominal deposit rate and reserve variation) present an ambiguous behavior, the quartiles of the distressed are separated only some years. GDP pro capita and the nominal deposit rate present a low degree of overlapping of the quartiles only in the year of the crisis,the reserve variation only four years before. The third couple of variables (CAD/GDP and M2/reserves) by means of the quartile analysis, do not appear strongly overlapping and should be studied further. Tables 3 shows the transvariation probability indexes respecting the categories selected by the quartile analysis. The rejected variables from the quartile analysis, are the ones labeled 'high transvariation', showing the fact that quartile analysis can be considered an elementary analysis of transvariation. The variables that, according to the quartile analysis had a partial or very little overlapping area, are the ones labeled 'low transvariation'. The low transvariation probability index is a necessary, but not sufficient condition in order to establish the predictive power of the single variable. The index, in fact, should be not only low, but also monotonically decreasing in time as the crisis approaches. From a descriptive statistics point of view this means that the overlapping area between the distribution of the two groups of countries diminishes with respect to that indicator. Reading table 3, we notice that both CAD/GDP and M2/reserves transvariation probability indexes diminish as we approach the year of the crisis. According to both variables the distribution of the distressed group of countries becomes more and more distant from the distribution of the sound countries approaching the year of the crisis, but CAD/GDP seems to be the best indicator because it presents the lowest values of the index starting from two years be-

fore the crisis. Finally table 2 lists those variables that have an ‘ambiguous behavior’, i.e. those variables that present high and low transvariation indexes that are not at all linked with the proximity of the crisis, the indexes do not monotonically decrease and cannot be considered as good predictive variables.

7.3 The speed of run

Once individualized the correct variable (CAD/GDP) it is necessary to explain how to use it correctly in a dynamic and not only static framework. Rationale of this procedure is that the persistence of the sign is a proof of an increasing intensity of the variable and vice versa. Most of the distressed countries experienced current account deficits for a long span of years continuously. Their speed of run is consequently very high. The most prominent cases are those of Indonesia, Malaysia, Philippines, Thailand, Peru and above all Argentina. The speed of run has been more modest for Korea and Ecuador, for Ukraine we don’t have all the data and in Mexico’s case we only consider four years before the crisis. The great exception is Russia and Venezuela with speed zero (even if its surpluses decrease monotonically). In table 4 the current account sign and the speed of run score are reported. The speed of run helps also to understand why Turkey - a very relevant country according to the size of its economy, population and exposure toward the international financial system - has been wrongly classified as risky as other South-East Asian countries and Argentina. Factors at the base of this misleading classification are: hyperinflation, very high public deficit, recurrent deficit of current accounts in time. This wide spread misunderstanding of Turkey’s probability of default is immediately corrected if the speed of run is considered. From table 4 we notice the difference in the score between Turkey (2) and Argentina (10).

8 Results: Frankel and Rose (1996) dataset

This section reports the results related to the rich sample taken from Frankel and Rose (1996), that is defined on a more 'loose' definition of country crisis. The results are summarized only by the transvariation probability index, seeing as we are considering all the observations in a span of time that goes from three years before the crisis to the year of the crisis. From the transvariation probability index we notice that also in this sample, the variable CAD/GDP has the most informative power compared to the other variables its index is 0.44, which means a low degree of overlap between the distributions of sound and distressed countries. The growth of M2 and the GDP pro capita growth also present a relatively low transvariation probability index.

9 Conclusions and further research

In this paper we have made use of a statistical methodology called 'transvariation analysis', developed by the Italian statistician C. Gini, to study and assess the predictive power of macroeconomic variables in the forecast of financial crises in developing countries. Two groups of countries, sound and distressed, have been formed. For each country composing the two groups we selected a range of macroeconomic indicators, broadly used in the literature, and then, with these indicators, we constructed a correspondent couple of distributions with respect to the two groups of countries. Because the core of transvariation analysis is the measurement of the overlapping of the two distributions our procedure is made of three steps. The first is the comparison of the quartiles of the distributions according to which a subset of variables - trade balance/GDP, investment/GDP, savings/GDP, M2/GDP, Domestic Credit/GDP, Inflation - has been eliminated. The second step is the calculation of the transvariation probability index in the four years leading to the crisis. The predictive power of the index has to involve low and decreasing values of it. According to this step the CAD to GDP ratio has been selected as the highest predictive power indicator of financial crisis. Because the distressed country analysis is developed on the basis of several years, it is necessary to join the use of the current account deficit variable with the counting of its speed of run. As data confirms the score of the speed supplies a good measure of the intensity of current account deficit in time. In order to test the robustness of this result on a different sample, we decided to calculate the transvariation probability index on Frankel and Rose (1996) sample of over one hundred developing countries that experienced a currency crash (measured in terms of a substantial depreciation of the nominal exchange rate). Even considering this broad definition of crisis we have proved that CAD/GDP is still the macroeconomic indicator with the highest predictive power according to this statistical methodology. Because Gini also extended the analysis of transvariation to the case of two and more variables, it might be fruitful in the future to apply the multivariate version of this statistical tool to select a multivariate leading indicator for financial crises. The aim of multivariate transvariation

analysis is to create a composite variable (or artificial variable) that synthesizes the single variables. The first step is to project the units of the two groups of countries (distressed and sound), which are now n-dimensional units, on a line, the second step is to apply univariate transvariation analysis to the two groups of countries with respect to the artificial variable created.

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Table 2: *Quartile analysis by variable*

trade balance/GDP					investment/GDP (variation)				
	-4 years	-2 years	crisis	control		-4 years	-2 years	crisis	control
1Q	-3.6	-4.0	-0.3	-2.1	1Q	-5.0	-5.3	-9.9	-1.0
Me	-0.5	-0.3	2.8	2.3	Me	-1.0	-0.9	-4.5	0.7
3Q	3.4	5.2	8.1	4.1	3Q	3.4	2.6	1.3	2.8
savings/GDP (variation)					GDP growth				
	-4 years	-2 years	crisis	control		-4 years	-2 years	crisis	control
1Q	-7.2	-11.0	-4.9	-7.2	1Q	2.8	-1.6	-18.0	1.7
Me	-0.4	-0.9	-2.6	-0.5	Me	8.7	8.9	-5.1	3.1
3Q	5.2	1.1	1.4	2.3	3Q	13.1	15.8	-2.1	4.1
reserves variation					CAD/GDP				
	-4 years	-2 years	crisis	control		-4 years	-2 years	crisis	control
1Q	8.4	-11.3	-37.3	-30.7	1Q	-4.5	-6.2	-4.5	-1.7
Me	20.2	13.0	-22.6	-10.4	Me	-3.2	-3.2	-3.0	1.2
3Q	34.0	31.3	-10.3	12.0	3Q	-1.3	-1.9	-1.8	4.0
M2/reserves (variation)					real deposit rate (variation)				
	-4 years	-2 years	crisis	control		-4 years	-2 years	crisis	control
1Q	-18.5	-11.7	4.0	-13.1	1Q	-59.2	-81.9	-59.3	-47.1
Me	-1.2	1.3	24.4	-9.4	Me	-2.2	29.6	-3.9	-30.0
3Q	2.0	25.6	38.8	-2.0	3Q	2.7	83.6	94.4	-15.3
domestic credit/GDP (variation)					M2/GDP (variation)				
	-4 years	-2 years	crisis	control		-4 years	-2 years	crisis	control
1Q	-1.8	-1.3	-3.7	-5.1	1Q	-11.1	-2.9	-3.5	-3.2
Me	4.3	4.2	6.6	3.0	Me	2.6	3.8	0.0	1.1
3Q	8.1	9.0	16.2	4.3	3Q	12.6	6.8	7.6	6.0
nominal deposit rate(variation)					inflation (variation)				
	-4 years	-2 years	crisis	control		-4 years	-2 years	crisis	control
1Q	-22.6	-11.0	1.8	-33.2	1Q	-28.9	-51.4	-27.7	-33.4
Me	-5.1	0.7	12.7	-20.0	Me	0.0	-15.5	-2.2	-0.5
3Q	0.0	13.7	44.0	-12.3	3Q	24.6	9.2	46.3	32.0

Table 3: *Transvariation probability index*

high transvariation					
	-4 years	-3 years	-2 years	-1 year	crisis
Trade Balance/GDP	0.84	0.75	0.90	0.90	0.79
Investment/GDP(variation)	0.80	0.90	0.85	0.91	0.57
Savings/GDP(variation)	1	0.93	0.91	0.85	0.92
M2/GDP	0.92	0.91	0.91	0.44	1.00
Domestic credit/GDP	0.83	0.92	0.82	0.53	0.74
Inflation (variation)	0.93	0.91	0.78	0.72	0.93
low transvariation					
	-4 years	-3 years	-2 years	-1 year	crisis
CAD/GDP	0.54	0.46	0.49	0.40	0.41
M2/reserves	0.84	0.61	0.69	0.49	0.41
high and low transvariation					
	-4 years	-3 years	-2 years	-1 year	crisis
Reserves variation	0.57	0.71	0.69	0.72	0.70
Nominal Deposit rate (variation)	0.64	0.82	0.51	0.66	0.19
Real Deposit rate (variation)	0.62	0.94	0.58	0.77	0.73
GDP pro capita growth	0.55	0.34	0.66	0.90	0.29

Table 4: *Speed of run of the current account deficit*

	90	91	92	93	94	95	96	97	98	99	00	score
Indonesia	-	-	-	-	-	-	-	-	+	+	+	7
Malaysia	-	-	-	-	-	-	-	-	+	+	+	7
Philippines	-	-	-	-	-	-	-	-	+	+	+	7
Korea	-	-	-	+	-	-	-	-	+	+	+	3
Thailand	-	-	-	-	-	-	-	-	+	+	+	7
Pakistan	-	-	-	-	-	-	-	-	-	-	-	8
Brazil	n.a.	n.a.	n.a.	n.a.	-	-	-	-	-	-	-	5
Mexico	-	-	-	-	-	-	-	-	-	-	-	4
Ecuador	-	-	-	-	-	-	+	-	-	+	n.a.	1
Venezuela	+	+	-	-	+	+	+	+	-	+	+	0
Russia	n.a.	n.a.	n.a.	n.a.	+	+	+	+	-	+	+	0
Ukraine	n.a.	n.a.	n.a.	n.a.	n.a.	-	-	-	-	+	n.a.	3
Ivory Coast	-	-	-	-	-	-	-	-	-	n.a.	-	9
Peru	-	-	-	-	-	-	-	-	-	-	-	10
Argentina	+	-	-	-	-	-	-	-	-	-	-	10
Turkey	n.a.	n.a	n.a.	n.a.	n.a	-	-	-	+	-	-	2

Table 5: *Transvariation probability index*

	index
CAD/GDP	0.44
M2growth	0.50
GDP pro capita growth	0.65
Government debt (p.c. GDP)	0.80
Investment/GDP(variation)	0.88
Reserves variation	0.89
Domestic credit/GDP	0.94
Short term debt (p.c. GDP)	0.95
External debt (p.c GDP)	0.97
Inflation (variation)	1